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"LUNGWORMS"

A PRELIMINARY REPORT ON TREATMENT, WITH SOME OBSERVATIONS REGARDING THE EPIDEMIOLOGY AND LIFE HISTORY OF THE PARASITE

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Introduction.—During the last few years a disease known as "lungworms," *verminous bronchitis,* or *pulmonary strongylosis,* has become a problem of distinct importance to California stockmen. This disease is caused by thread-like worms which infest the tracheae, bronchi, and bronchioles (air passages of the lungs). Calves, goats and swine are the chief hosts of these parasites.

The three species of lungworms which are of economic importance belong to the sub-family *Metastronglinae* of the class *Nematoda,* and were previously all included under the genus *Strongylus.* This genus has been divided, so that at the present time, the three species are known as *Dictyocaulus viviparous* (Bloch) affecting calves, deer and rarely sheep; *Dictyocaulus filaria* (Rudolphi) affecting sheep, goats, camels, deer and sometimes calves; and lastly *Metastrongylus apri* (Gmelin), the corresponding parasite of swine. The adult worms of these three species are very similar in structure, differing mainly in size.

The above named species are the only ones that have come to the attention of the Parasitology Laboratory of the Experiment Station and although there are two others associated with domestic animals, *D. arnfieldi* (Cobbold) infecting horses and asses, and *Metastrongylus brevivaginatus* (Raillet and Henry) affecting pigs, it is doubtful if they occur in California. These five parasites complete the list of nematodes of economic importance infesting the bronchi and bronchioles exclusively during their adult life, but two other genera of nematodes, *Synthetocaulus* and *Haemostrongylus,* are sometimes present in the lungs,—the former in the lung tissue and the latter in the pulmonary artery.

The lungworm of calves, *Dictyocaulus viviparous,* is a slender, whitish, thread-like worm. The male is about one and one half inches long and the female varies from two and a half to three and a quarter inches.

Dictyocaulus filaria, the lungworm of sheep and goats, is the largest of the three, ranging from two and a half to three inches in length in the case of the male, while the female is sometimes three and a half to four inches long.

Metastrongylus apri, found in swine, is much smaller than either of the others described. The male is scarcely three quarters of an inch in length and the female rarely exceeds two inches.

While the parasites themselves often cause the death of the animals by suffocation, their chief danger lies in the fact that an infested animal is an easy victim to pathogenic organisms because of the unnatural condition of the lungs due to the worms. The worms, when present in great numbers, often cause the collapse of portions of the lung tissue by blocking the bronchi, which supply air to those portions, thus producing favorable media for the development of bacteria. Broncho-penumonia, so often associated with an infestation of lungworms, undoubtedly owes its origin to this circumstance.

Symptoms.—The animals affected invariably have a more or less violent cough, hard at first but becoming softer and occurring in paroxysms; frothing at the mouth may also be noted sometimes. The animals stand or lie with their necks extended and in pronounced cases they are noticed to breathe with difficulty. They are generally extremely weak and short of breath, falling to their knees if hurried in the drive. The temperature varies but does not become exceedingly high. These form, perhaps, all the clinical symptoms that can be given and unlike many parasitic infestations, all the symptoms are generally present.

The exception must be made, however, in the case of swine. The symptoms here are, if noticeable at all, never accentuated and a post-mortem examination is generally necessary to confirm a diagnosis of "lungworms."

Treatment.—It has been the common practice among some stock raisers when an infestation of lungworms occurs to subject those animals which they believed would succumb to the ravages of the parasite, if untreated, to a treatment consisting of inhaling the dust of air slacked lime or sulphur fumes. This heroic treatment generally resulted in saving a few of the animals, but the majority usually succumbed under treatment. However, the rancher reasoned that to save a few was better than losing them all.

Lungs of a goat, showing the lungworms in the trachea.

With this idea in mind, that it might be possible to have the infested animal breathe vapors or liquids that would destroy the worms and leave the animal unaffected, Mr. E. M. Ledyard, a graduate student, started a series of experiments under the direction of the senior author, to ascertain what remedies might safely be used in this way. Various chemicals, including turpentine, benzine, chloroform and other substances were used separately and in various combinations. The method of administering the doses was varied by trying both nasal and tracheal injections.

The result of these tests proved that pure chloroform administered in each nostril by means of a pipette was most effective. The amount administered to each animal must needs be a variable quantity, depending upon the age, resistance and general condition of the individual animal. Among the first animals treated was a herd of 150 angora goats. In the fall of 1914, Mr. Ledyard and the junior author successfully treated these with one and a half cubic centimeters of chloroform in each nostril, thus totaling three cubic centimeters per animal. In every instance the animal became slightly anaesthetized for a period varying from two to twenty minutes, but no bad results developed in the herd, which after two more treatments became apparently free from lungworms.

At that time it was supposed that the chloroform actually *killed* the lungworms *in situ* and that they were eliminated by coughing. Later developments, however, show that the chloroform merely stupefies the worms and at the same time irritates the throat and windpipe, thus causing a prolonged paroxysm of coughing during which the worms are coughed up and swallowed.

In the first experiments it was attempted to find a standard dose of chloroform that could be recommended to the rancher with assurance of safety and effectiveness. Later experiments have proved the impossibility of this, for one animal has been found to require five times the amount of chloroform needed to produce the same effect in another.

This variability has led to our present practice of administering enough chloroform (within certain limits) to make the treated animal slightly "groggy." The maximum dosage has been eleven cubic centimeters for calves and three cubic centimeters for goats.

The animals to be treated should be confined in a corral which is free from grass and other vegetation. The chloroform is best administered by tipping back the animal's head and injecting the desired dose of chloroform with a small pipette (an ordinary fountain pen filler will be found satisfactory). Half the dose is administered in

each nostril. The action of the chloroform is enhanced by stopping the nostrils with the hand or cotton plugs for a few moments after injection.

Two hours after the treatment a saline purge of Epsom or Glauber's salts should be given the animals. Feces should be carefully disinfected by frequent and liberal sprinklings with chloride of lime.

Feed and watering troughs should be so constructed in the corral that pollution with feces will be impossible. Treatments should be continued at intervals of three to five days until the animals improve. Three treatments is the maximum number that we have needed to use in any of our experiments.

In England, where chloroform is the chief anaesthetic, many cases of necrosis of the liver have resulted from prolonged chloroform anaesthesia. This problem naturally led to some hesitation in suggesting the above method of chloroform treatment for lungworms, but several post-mortem examinations of treated animals which revealed perfectly healthy livers seem to discount the danger.

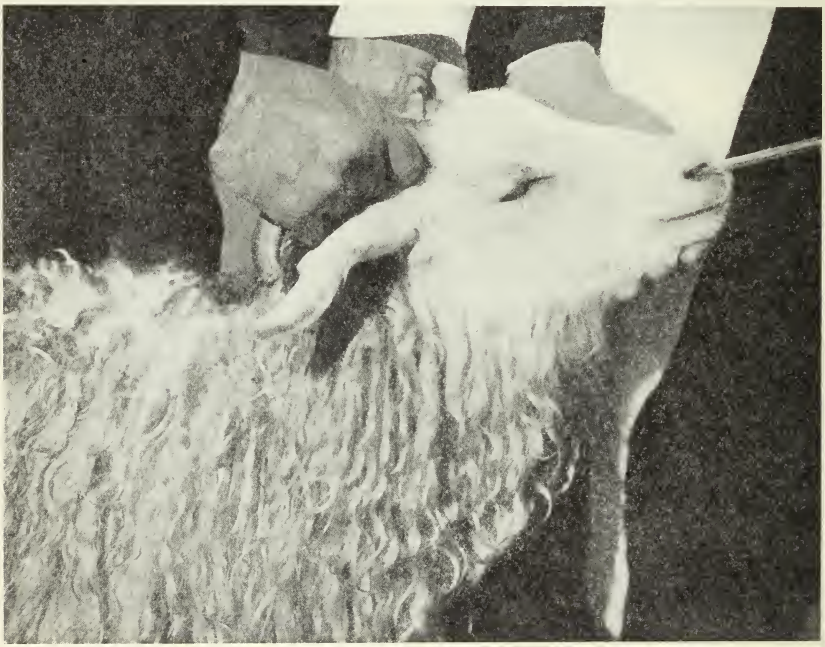
Life History.—The life history of these parasites has never been entirely worked out and it is only within the last few years that any valuable contributions have been made to the subject.

Early in our investigations we observed that the embryos found in the lungs were of two distinct types. Our first thought was that these might be embryos of two different species of lungworms, but this was discounted by the fact that we could find but one species of adults in the lungs. That the differentiation might be due to sex was rejected owing to the fact that the types differed not only in shape and structure, but also in their movements, location and habits. Thus the theory gained belief that these two types were designed to maintain a free-living and a parasitic generation. This belief was confirmed by Doctor von Linden[1] of the University of Bonn, who found that in the mucus of the trachea and of the space behind the nose there were slim, strong-moving embryos that were capable of living outside the body. In the lungs the embryos were short, thick, slow moving, and unable to live outside the body.

Dr. von Linden found that if the slim, strongly moving larvae are placed on moistened earth they continue their development and she has been able to raise eleven successive free-living generations in this way.

[1] Von Linden, Gräfin. Untersuchungen über die Entwickelung der freilebenden Generationen der Lungenwürmer. Centralblatt für Bakt., Parasit., und Infekt. Orig. Bd. 76, Nr. 2–3, pp. 147–178 (20 May, 1915).

Dr. von Linden believes that the embryos, intended to reproduce the free living generations, work their way up the trachea and are swallowed and excreted from the body with the feces. The embryo then molts and withdraws within its cast skin, which forms a sort of cyst, protecting the larva from extremes of heat or cold and dryness until conditions are suited to its growth. Under favorable conditions the second generation of worms appears in from four to six weeks and further generations continue to appear at this interval for about four



Goat infested with lungworms being treated with chloroform by means of a bulb pipette.

months. This period of increase is generally followed by a standstill of about three months when the period of increase again starts. The thick, slow-moving embryos die almost immediately when placed outside the body.

The presence of this free-living type of the parasite discovered by Dr. von Linden and partly confirmed by our own observations, would explain the major part of the hitherto unknown life history. Experiments attempting to confirm and duplicate Dr. von Linden's work are now under way.

Accepting the presence of a free living generation there remains only one dark point in the life history. That is the method by which stock becomes infested. The most logical method would seem to be that the larvae find their way into the nostrils from the ground or are snuffed up as encysted larvae in dust, for the larvae, when subjected to excessive dryness, are said to encyst within their cast skins. The other belief is that they are swallowed and burrow their way through some point in the alimentary canal and are carried thence to the lungs.

Epidemiology.—The epidemiology and the control are so closely linked that the history of two typical cases that have come under the writers' observation are included.

The angora goats mentioned above contracted the infestation practically simultaneously when pastured on a range free from other domesticated animals and where lungworms had not previously been observed. They were purchased from a flock free from lungworm and transported directly to their pasture. Deer were prevalent in that part of the country and some were shown to be infested with the same species of lungworm (*D. filaria*), that the goats contracted. Deer were seen to use the same drinking places frequented by the goats and hence the logical conclusion was that the goats became infested from the deer.

Another instance showed four calves which had been placed on a heavy clover pasture directly after weaning. This farm had a history of lungworm the year before. In about four months all four calves became infested. Their pasture was open to no other animals, but they used the common drinking trough with the other farm animals. Cows are known to harbor lungworms, which, however, never cause any indisposition in these adult animals,—calves alone being seriously affected. It seems in this case as though an adult carrier may have been the source of the infestation, or more probably, according to von Linden, the infection was due to the free living type of the parasite which had been reproducing in the moist parts of the pasture.

Prophylaxis.—Regardless of the mode of infestation, the essential factor is to build up the general health of the stock, providing abundant food and proper shelter in order that they may resist any infestation of the parasites.

Infested animals should be isolated and all excrement from them should be properly sterilized. Healthy animals should not be quartered on pastures known to have a definite history of lung-worm infestation. Animals pastured on low, wet ranges become infested more readily than those on dry locations. If practical, measures should be taken to control possible carriers, cows and deer.

SUMMARY

1. Verminous bronchitis is caused by an infestation of nematode worms known as lungworms, each species of which has a favorite host, to which, however, it is not obligatory.

2. Other investigators have demonstrated free living generations of these worms which are capable of reproducing in moist soil and which are able to withstand drying in an encysted state.

3. Treatment by nasal injections of chloroform in amounts varying with the general condition of the animal, followed by a saline purge and feces sterilization, has proved very successful.

4. Deer and possibly cows may act as carriers and should be excluded from the pasture land of susceptible stock.

5. The general health of the stock is a determining factor in resisting an attack of the parasites. Every care should be observed to insure plenty of food and proper shelter.